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The Optimal Level of Foreign Reserves in Macedonia

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Abstract

During the last two decades the emerging countries have experienced an upward trend in reserve accumulation. However, high level of foreign reserve assets implies certain costs. Consequently, given the trade-off between the benefits and the costs of holding reserves, there are issues related to the adequacy of the current level of reserves. In this analysis we make an effort to assess the optimal level of the official foreign reserves in Macedonia. The estimation of the optimal level of foreign reserves is based on cost-benefit welfare model as in Jeanne and Ranciere (2011), in which reserves serve as an insurance for the economy and have two roles - to mitigate the negative effects of a capital account crisis (sudden stop) and to prevent future crisis. The model that captures the benefit of holding reserves as self-insurance assumes an exogenous probability of crisis. This basic model shows that the actual level of official reserve assets is above the level for crisis mitigation. In case when reserves are held not only for crisis mitigation purposes, but also for crisis prevention, the probability of crisis is endogenous and depends on the level of reserves. This extended model, which is more suitable for Macedonia regarding the exchange rate regime, shows optimal level of reserves that is still below, but close to the official foreign reserves in recent years.

Keywords: optimal reserves, sudden stop crisis, Macedonia, endogenous probability of crisis
JEL classification: F31, F32, F41

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Contents

1. INTRODUCTION

During the last two decades, emerging economies accumulated large amount of international reserves. The accumulation of reserves helped to smooth consumption during the recent and past crises, and enabled some countries to manage large outflows without experiencing a costly crisis (IMF, 2011). In addition, holding and managing adequate official foreign reserve assets can be used for crises prevention, driven by the volatility of the capital flows and the vulnerability of the countries to external shocks. However, holding reserves is costly, as there are costs related to the returns on the reserves (opportunity cost) and to the potential distortions on the domestic economy. Taking into account the trade-off between the benefits and the costs of holding higher level of international reserves, the key question that arises is related to the optimal level of foreign reserves assets. There is no single measure of the optimal level of reserves that country should hold. Different approaches can be met in the literature and they can be broadly divided into two broad groups - cover indicators and modeling approaches. According to the IMF survey on reserve management (IMF, 2011), the traditional metrics (cover indicators) are the most used ones. In the class of modeling approaches, there are different types of models; however the cost-benefit models for optimal reserves are prevailing in the literature. The most recent versions of the cost-benefit models are based on welfare analysis with representative economic agents that behave optimally. Among them, the model of Jeanne and Ranciere (2011) for small open economies in which the reserves serve as an insurance against sudden stops is one of the widely used in the literature.

Macedonia is small and open economy and, as other emerging countries, has registered an upward trend in the level of foreign reserves assets[1]. The level of official foreign reserves assets in Macedonia has reached almost 29% of GDP in 2012 and 2014. Indeed, as a country with *de facto* fixed exchange rate, holding foreign reserves is very important in order to offset the downward currency pressures, as well as to protect the country against balance of payment crisis. However, given the costs of holding reserves, this continuous accumulation of foreign assets poses the question of the adequacy of the current level of reserves. This analysis will try to give answers to this question. First, the reserve adequacy will be assessed on the basis of

[1] In the paper, the terms: international reserves, official foreign reserves, foreign reserves and foreign reserve assets refer to same category and are used interchangeably.

the cover indicators which are already used by the NBRM. Second, a welfare based model for calculating the optimal level of official foreign reserves will be constructed. In this framework, the core Jeanne-Ranciere model is adopted, but modified for some country specific features. In the model, the foreign reserves are held for two reasons - crisis mitigation and crisis prevention. The latter means that the probability of the crisis is endogenous to the level of reserves i.e. in order to reduce the probability the country has to accumulate more reserves. The construction of the cost-benefit welfare based model is the main contribution of this analysis. In this way, this study will complement the current analytical framework used at the NBRM for analyzing the adequacy of the foreign reserves.

This analysis is organized in the following way: In the second section, the stylized facts about developments in Macedonian foreign reserve assets are given, while in the third one, the literature overview is exposed. The fourth section gives an overview of reserve adequacy using the traditional metrics, based on cover indicators. In the fifth section, the adopted model for optimal level of foreign reserves is explained, including the model calibration, the results and the sensitivity analysis. The final conclusions are given in the last section.

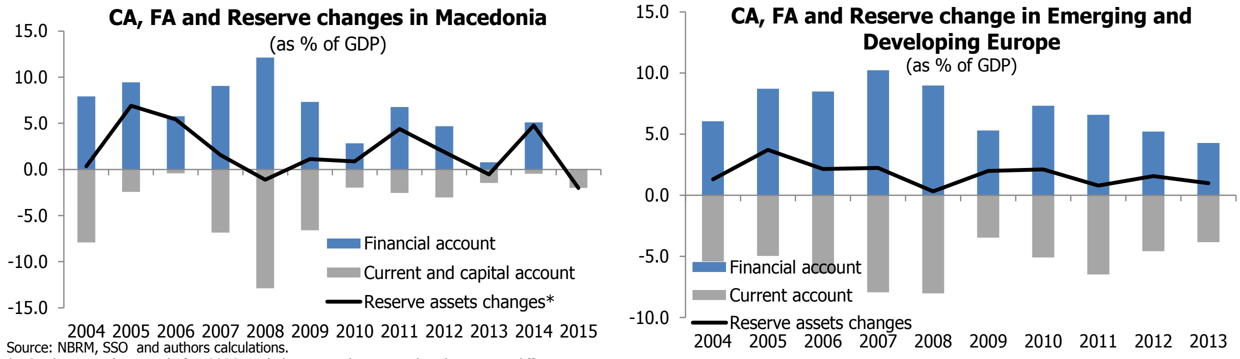
2. MACEDONIAN FOREIGN RESERVES DEVELOPMENTS

Since October 1995, the National Bank of the Republic of Macedonia (NBRM) started implementing the monetary strategy of targeting the nominal exchange rate of the Denar against the Deutsche Mark, and since January 2002 - against the Euro. Accordingly, intermediary objective of the monetary policy is the maintenance of the Denar exchange rate stability. In line with the chosen monetary strategy, building foreign reserve assets was essential.

Gross official foreign reserves were increasing almost continuously since the independence of Macedonia, which contributed to building the stock of the reserves. The analysis of the balance of payment shows that in the case of Macedonia, as well as for the emerging European countries, the accumulation of the foreign reserves is due to net financial inflows, which surpasses the current account deficits (see Figure 1). The structure of the financial inflows in Macedonia points out that the largest part of net financial inflows is coming from foreign direct investments (on average about 4% of GDP in the period 2004-2015) and represents more than

60% of total net financial inflows. Other investments also have significant share in reserves accumulation, among which loan and trade credit liabilities are the most important (see Appendix 1, Figure 3).

Figure 1[2]



Source: NBRM, SSO and authors calculations.
* BOP data. For the period after 2006, excluding price changes and exchange rate differences.

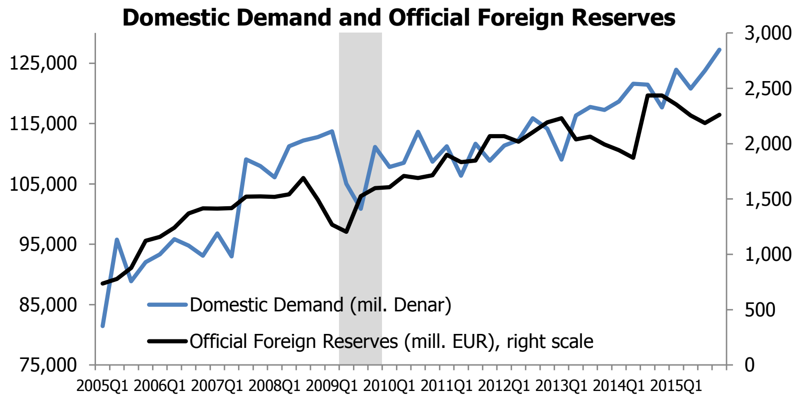
Source: WEO October 2016 and authors calculations.

In 2008, the current account balance deteriorated severely, which caused an increase in the demand for foreign currency on the Forex market. Two events contributed to this result. First, at the beginning of 2008, the domestic economy faced a confidence shock. In line with the intensification of inflation, inflationary expectations have increased, as well, and there were speculations on possible Denar devaluation. In such circumstances, the investments in foreign currency were alternative for preservation of the income value and this resulted in sharp decline in net purchases of foreign currency on the exchange market (cash exchanged), which is the most important item of the private transfers[3] in the Balance of Payments Statistics. Private transfers are one of the major surplus component within the current account. The stabilization on the markets was achieved in the next period, given the gradual stabilization of the inflation, the higher capital inflows and the traditionally high private transfers' inflows from abroad in the third quarter. Second, the effects of the global crisis became stronger in the Macedonian economy at the end of 2008 and continued during the first half of 2009, with strong negative impact on trade at the beginning and on financial inflows from abroad in the later period, which created depreciation pressures on the domestic currency. In order to maintain the stability of the exchange rate, the shortage of foreign currency was covered by the NBRM intervention on the Forex market. In total, as a result of these shocks, the stock of foreign reserves decreased

[2] According to the IMF WEO database, the data for Emerging and Developing Europe refer to the following countries: Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Hungary, Kosovo, Macedonia, Montenegro, Poland, Romania, Serbia, and Turkey.
[3] According to the NBRM Methodological notes for Balance of Payments Manual (BPM 5), private transfers consist of: remittances, cash exchanged and other transfers of which the most are rents. For more information, see NBRM Methodological notes for Balance of Payments - Methodology BPM 5 (http://www.nbrm.mk/WBStorage/Files/Statistika_BOP_methodology_29_11_2013.pdf)

by 2.9 percentage points in terms of GDP in 2008, which was the highest decline observed up to that period. Given the fall in trade and financial borrowing constraints on the domestic agents, domestic absorption also decreased significantly during 2009. However, the NBRM interventions on the FX market provided enough foreign liquidity for the economy, and along with additional monetary policy measures and with external government borrowing (issuance of Eurobond and allocation of the Special Drawing Rights-SDR), helped in stabilization of the markets and in domestic absorption smoothing.

Figure 2

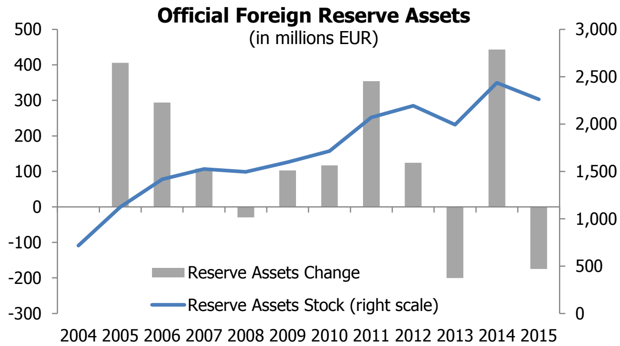


Source: NBRM, SSO and authors calculations.

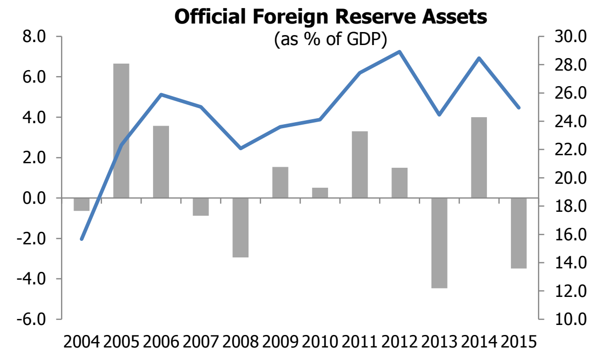
After the stabilization of the domestic macroeconomic developments, foreign reserves were back to their upward path. Hence, foreign reserves reached up the level of Euro 2,193 million at the end of 2012 or almost 29% of GDP, which is historically the highest level (Figure 3). In the next years, the level of reserves was volatile[4], but the change of reserves was not accompanied by domestic absorption fall. At the end of 2015, the official reserves stood at level of 25% of GDP.

[4] There was a strong fall in official reserves in 2013, which was not a result of some economic developments, but mostly due to negative price and exchange rate differentials. The new high level of reserves of Euro 2,436 million (28.5% of GDP) was achieved in 2014, when the third Eurobond was issued. Those accumulated assets along with assets from the Eurobond issued in late 2015 were used for public debt repayment, which was the main factor for reserves depletion in 2015.

Figure 3



Source: NBRM and authors calculations.

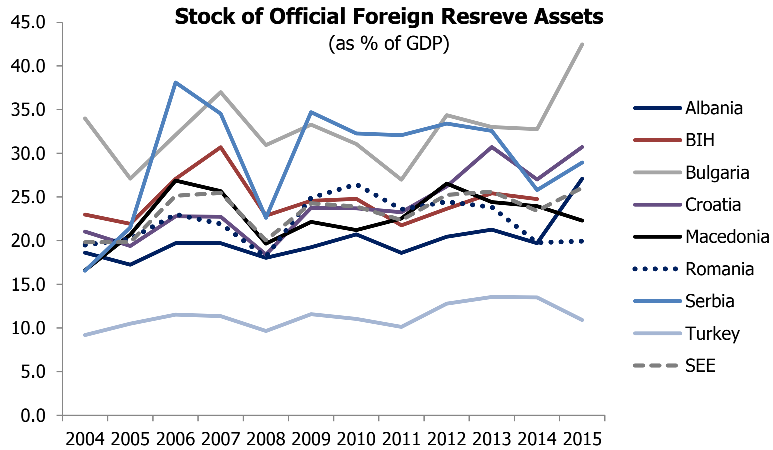


Source: NBRM, SSO and authors calculations.

The dynamics of the Macedonian foreign reserves during the global crisis is very similar to those of the SEE countries (Figure 4). Namely, most of the countries registered strong fall in reserves at the end of 2008 when these countries have felt the first negative impact of the financial crisis. Furthermore, we would like to explore the relationship between the reserves and the exchange rate regime among these countries[5]. Foreign reserves holdings usually are higher in the countries with fixed exchange rate and lower in the countries with flexible exchange rate. Thus, Turkey and Albania, which have the lowest level of foreign reserves, are the clear example for countries with flexible exchange rate. Additionally, during the crisis, the reaction of the countries is stronger (sharper fall in reserves) in those with fixed exchange rate, with the exception of Serbia, which also intervened heavily on the Forex market in order to reduce the strong daily volatility in the exchange rate.

[5] According to the De Facto Classification of Exchange Rate (ER) Arrangements and Monetary Policy Frameworks, given in the IMF publication "Annual Report on Exchange Arrangements and Exchange Restrictions 2016", Bulgaria and BiH are countries with currency board, Macedonia is classified as country with stabilized ER arrangements, Croatia with crawl-like ER arrangements, and the rest of the countries are classified as countries with floating ER arrangements. According to this, in our analysis, the countries mentioned above are classified as countries with fixed exchange rate.

Figure 4



Source: IFS database and authors calculations.

3. LITERATURE OVERVIEW

During the last two decades, emerging economies accumulated large amount of international reserves - reserves in the emerging markets have grown to more than 20% of GDP in the period 1990-2005 (Jeanne, 2007). This trend resulted in a vast number of empirical studies that try to investigate the reasons behind the high reserves accumulation. Several motives for foreign reserves accumulation can be met in the literature. First, from insurance perspective, countries hold reserves in order to limit the volatility of the exchange rate, smooth consumption in case of balance of payment shocks and provide liquidity for the domestic financial markets (Jeanne and Wyplosz, 2003). Second, many emerging countries, at least for a certain period, want to pursue an export-led growth, supported by, de jure or de facto, anchored nominal exchange rate to the US dollar (ECB, 2006). Third, it has been argued in the literature that international reserves might decrease the likelihood of the crisis i.e. reserves install confidence effect and could have preventive role. On the other hand, holding reserves is costly - there are domestic risks and costs associated with inflationary pressures, over-investment, complication in the management of the monetary policy, segmentation of the public debt market, sterilization costs and misallocation of domestic banks' lending (ECB, 2006). One more additional cost discussed in the literature is the opportunity cost of holding reserves i.e. the cost related to the more profitable illiquid investment opportunities (Jeanne, 2007). Having in mind this trade-off between the benefits and the costs of holding higher level of international reserves, the question of the optimal level of reserves arises as a key issue for every country.

Different approaches for calculating the optimal level of reserves can be met in the literature. They can be broadly divided into two broad groups - cover indicators and modeling approaches. Traditionally, the adequacy of the reserves has been judged by constructing simple ratios or cover indicators such as ratio of reserves to imports, ratio of reserves to short-term debt (Guidotti ratio), ratio of reserves to money supply, etc. These indicators are transparent, intuitive and easy to construct. However, they have rather narrow explanatory power because they concentrate only on one dimension (export or short-term debt, for example). Additionally, they have been criticized for being very arbitrary i.e. these simple "rule of thumb" indicators lack fully developed analytical foundations. Also, the ratio indicators failed to explain the high reserve accumulation in the emerging markets in the last two decades (Jeanne, 2007; IMF, 2011).

Many empirical studies tried to explain the high build-up of reserves in the early 2000s by using regression-based models based on the estimation of the precautionary demand for reserves. The model specification usually includes the following explanatory variables: economic size of the country, current and capital account vulnerability and exchange rate volatility. Aizenman and Marion (2002) find out that reserve holdings can be predicted relatively well by few key factors, such as the size of international transactions, their volatility, the exchange-rate arrangement, and political considerations. However, the model significantly underpredicts the high reserve accumulation after the 1997 financial crisis. Similar findings are reported in the analysis made by the International Monetary Fund (IMF, 2003) - GDP per capita, population, imports/GDP ratio and exchange rate volatility were found to be significant determinants of reserve holdings in emerging countries; on the other hand, these variables seriously underestimate high reserve accumulation in Asia since 2000.

The empirical failure of the cover indicators and the regression models to explain the recent foreign reserves accumulation in emerging countries inspired the use of cost-benefit models for optimal reserves. In fact, these models were developed much earlier, during the 70s. Heller (1966) derived the optimal level of reserves by contrasting the opportunity cost to the costly adjustment if crisis occurs - the costly adjustment being defined as a contraction in domestic absorption. Within this framework, the optimal level of reserves is the one that minimizes the sum of the expected adjustment costs. Later, Frenkel and Jovanovic (1981) developed the "buffer stock model" in which the optimal level of reserves depends on the variability of international transactions - the more variable the international transactions are, the higher the level of international reserves that the country needs[6]. On the other hand, international reserves, in the "buffer stock model" are negatively correlated with carrying costs[7]. More recent versions of the cost-benefit models are based on welfare analysis with representative economic agents that behave optimally. Durdu et al. (2009) build dynamic stochastic general equilibrium model for optimal precautionary demand for foreign reserves. They investigate the dependence of the foreign reserves on three key factors - the business cycle, financial globalization and self-insurance against the risk of sudden stops and conclude that the financial globalization and the risk of sudden stops can explain preferences for high reserve holdings in emerging markets. Caballero and Panageas (2007) use general equilibrium framework to model the behavior of the emerging markets. In their model emerging markets persistently run current account deficits that had to be financed by capital inflows or by borrowing from developed countries. However, the developed countries are not always willing to lend to the emerging countries depending on the negative shocks to preferences, technology and output. These negative shocks in the model result in sudden stop of capital inflows in the emerging markets. Within this framework, emerging markets must have some form of insurance against the sudden stop i.e. they accumulate foreign reserves in "good" times in order to absorb the negative effects in "bad" times. Jeanne and Ranciere (2011) developed a welfare based insurance model for small open economies in which the reserves serve as an insurance against sudden stops. Within this framework, the optimal level of reserves is pinned down from the government objective function, i.e. the government maximizes the welfare of the economy by choosing the level of international reserves subject to the overall budget constraint. They conclude that the reserve accumulation in Asia after the financial crisis can be explained by large anticipated output cost accompanied by high level of risk aversion.

To model the optimal level of reserves for Macedonia we use the core Jeanne-Ranciere model modified for some country specific features. In the model, reserves are held for two reasons -

[6] This model is also called "the inventory model".
[7] Carrying costs are the total cost of holding some type of inventory. This includes warehousing costs such as rent, utilities and salaries, financial costs such as opportunity cost, and inventory costs related to shrinkage and insurance.

crisis mitigation and crisis prevention. The latter means that the probability of the crisis is endogenous to the level of reserves i.e. in order to reduce the probability of crisis the country has to accumulate more reserves.

4. TRADITIONAL METRICS FOR ASSESING ADEQUATE LEVEL OF RESERVES FOR MACEDONIA

The traditional metrics are based on simple rules of thumb. They are transparent, intuitive and easy for calculation, which makes them the most used indicators of reserve adequacy (IMF, 2011). On the other hand, they are perceived as arbitrary by their nature, narrow in scope as they focus only on a particular aspect of vulnerability, and give divergent results. The traditional metrics include the following ratio indicators: reserves to imports, reserves to short-term external debt and reserves to a broad measure of money (typically M2), as well as the combination metrics[8]. We continue with short explanation for each of the metrics and analysis of each indicator for Macedonia. The indicators for Macedonia are presented in Figure 5.

Reserves to imports. The reserves to imports ratio is considered as most relevant for countries exposed to current account shocks and restricted access to capital markets. The benchmark is **three months coverage** of prospective import. For emerging economies with pegged exchange rate, the benchmark is usually set at coverage level of four months of import, in regard to their higher vulnerability to external shocks. In the case of Macedonia, we are calculating the monthly coverage of current year import and of next year imports, and give comparison with 3 months and 4 months benchmark. As shown in Figure 5 the actual level of reserves is above the indicator in the whole analyzed period (2004-2015).

Reserves to broad money (usually M2). This indicator is most relevant for countries with managed exchange rates. This metric captures the risk of capital flight, the confidence in the value of local currency, but it may also be seen as a measure of potential need for bank support during or after a crisis. The benchmark is in the **range of 5%-20% coverage** of broad money. The analysis for Macedonia contains two indicators of this type - reserves/M2 ratio and reserves/M4. Both calculations show high adequacy of the reserves, as the reserves exceed the upper boundary of 20% coverage for almost 3 times.

[8] The benchmarks are from the IMF policy paper "Assessing Reserve Adequacy", 2011.

Reserves to short term debt (Greenspan-Guidotti rule). This ratio is the most preferred measure for measuring risk of a capital account crisis and it is more suitable for market access countries. The Greenspan-Guidotti rule is **100% coverage** of short-term debt at residual maturity (STD), which is the external debt becoming due within 12 months. Again, as with the previous indicators, the actual level of reserves in Macedonia is above or very close to the benchmark.

Combined metrics. These metrics are intended to capture a broader range of risks. Accordingly, these metrics require higher level of reserves to be held.

The most used is an **expanded Greenspan-Guidotti rule**, which expands the basic indicator for the current account deficit (STD minus CA balance). Defined in this way the indicator reflects the full need for financing in the 12-month period. According to the expanded Greenspan-Guidotti rule, in the first half of the analyzed period, the level of reserves is below the proposed benchmark. However, in the second half of the period, as the current account deficit declines, the actual reserves move closely/or are above the benchmark.

The IMF proposed new metrics (IMF, 2011), called **risk-weighted metrics**[9]. This metric is constructed on the bases of estimated relative riskiness of different potential drains on reserves. The distributions are estimated separately for fixed and floating exchange rate regimes. The construction of the risk-weighted liability stock is the following:

Fixed: 30% of STD + 15% of OPL + 10% of M2 + 10% of X

Floating: 30% of STD + 10% of OPL + 5% of M2 + 5% of X,

where STD stands for Short Term Debt (at residual maturity), OPL – Other Portfolio Liabilities (equity liabilities), M2 – Broad money M2 and X for Exports. The benchmark requires reserves **coverage in the range of 100%−150%** of the metric.

In the case of Macedonia, the risk-weighted liability stock was calculated on the base of metrics for countries with fixed exchange rate, but with some adjustments in the weights, that are related to the country specifics. As Macedonian economy has more trade integration than financial integration, there is higher risk to external demand and terms of trade shocks.

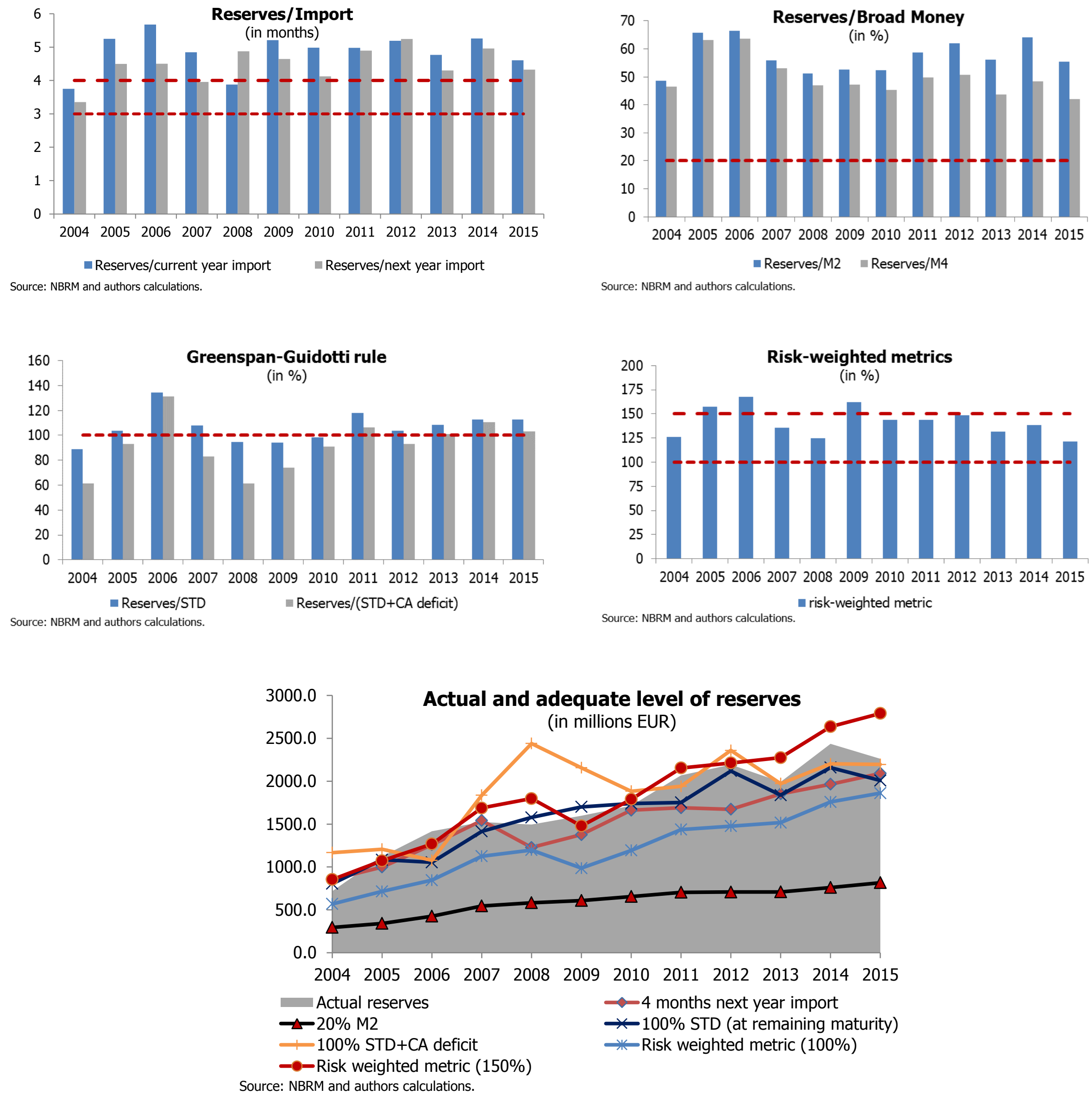
[9] We should notice that in the meantime, there are some changes in this metrics given in the guidance developed in the 2011 - Assessing Reserve Adequacy (ARA) policy paper, which regards to the weights and the comprehension of some of the components.

According to that, the weights in front of STD and export are changed, with higher weight in front of the export and smaller weight in front of STD. The adjusted metrics is the following:

Adjusted for country specifics: 10% of STD + 15% of OPL + 10% of M4 (Denar) + 30% of X.

The application of this metrics was made for the period 2004-2015 and results show adequate level of reserves during the whole period, i.e. the actual level of reserves moves within the range of 100%−150% of the metric.

Figure 5



In general, most of the cover indicators for assessing the adequacy of foreign reserves show that actual reserves are in line with/or above the benchmark indicators in the analyzed period. The actual reserves exceed the broad money indicator and the import coverage indicator almost in the whole analyzed period. Results are similar for the Greenspan-Guidotti rule, whereas the expanded Greenspan-Guidotti rule suggests slightly higher need for reserves than actual in the first half of the analyzed period. However, in the last five years, as the current deficit declines, the actual reserves are in line with, or slightly above the proposed benchmark. According to the risk-weighted metric, that covers more than one dimension of risk, the level of reserves moves within the range of 100-150% of the metrics, indicating that the actual reserves are at the adequate level for the analyzed period. In the next section, we proceed with the model for estimating the optimal level of international reserves with exogenous and endogenous probability of crisis.

5. MODEL FOR OPTIMAL RESERVES FOR MACEDONIA

The optimal level of international reserves for Macedonia will be derived from a cost-benefit, welfare-based framework as in Jeanne and Ranciere (2011) and Ceh and Krznar (2009). Within the model, reserves serve as insurance for the private sector and have two roles - to mitigate the negative effects of a capital account crisis and to prevent future crisis. On the other hand, there is an opportunity cost of holding higher level of reserves related to more profitable, but illiquid investments. Hence, the optimal reserves will be the welfare maximizing level of reserves given the benefits and the costs of holding reserves. In order to make the model more realistic, the core Jeanne-Ranciere model has been modified to capture some country specific features. Precisely, there are two sources of shocks in our model - the possibility of capital flows reversal, or a sudden stop crisis, and the possibility of private transfers' withdrawal, or a confidence crisis. These two shocks occur simultaneously.

This section is organized in the following way: In the first part we present the basic characteristics of the model and then we develop two model extensions - one in which we evaluate the effects of possible real exchange depreciation and one in which the probability of a crisis is endogenous and depends on the level of reserves.

5.1. Model for optimal level of reserves with an exogenous probability of crisis

The economy in the model consists of two groups of economic agents - the private sector and the government. We assume perfect competition and representative agents. The role of the government in the model is to maximize the welfare of the representative agents by deciding on the optimal level of international reserves. The optimal level of reserves is the level that provides optimal insurance against two external shocks. The first shock is defined as a 'standard' sudden stop crisis i.e. it is a negative shock in the financial account followed by capital withdrawal. The second is a shock in the current account and it assumes a decline in the primary and secondary income (income and transfers' account). This decline is mostly triggered by the drop in private transfers. As explained earlier, in the case of Macedonia, several historical episodes showed that the level of private transfers is very sensitive to changes in private agents' expectations and can change dramatically in a very short period of time. Hence, our negative shock to income and transfers can be interpreted as a negative confidence shock. The important role of the private transfers in financing the trade deficit in the balance of payment justifies their inclusion in the model for the optimal reserves. The two shocks occur simultaneously, with probability π. In the core version of the model the probability is exogenous i.e. it is independent of different policy decisions. Later we develop a version of the model where we endogenize the probability.

The private sector decides on its consumption and savings by maximizing its utility function subject to the budget constraint. The utility function is Von Neumann-Moregenstern utility function like in Jeanne and Ranciere (2011) and Ceh and Krznar (2008). The properties of this utility function is positive, but diminishing, marginal utility with constant relative risk aversion of σ. The constant relative risk aversion means that the risk aversion parameter has the same value irrespective of the level of consumption.

$$u(c) = \frac{c^{1-\sigma}-1}{1-\sigma} \quad (1)$$

The budget constraint of the private sector in normal i.e. non-crisis time is given as:

$$C_t^n = Y_t^n + FA_t^n + IT_t^n - X_t \quad (2)$$

where C_t^n is the total consumption[10], Y_t^n is domestic output, FA_t is the total financial account excluding reserve assets changes, IT_t stands for the net income and transfers and X_t is a transfer from the government. To express the financial account and income and transfers as percent of GDP we modify equation (2)

$$C_t^n = Y_t^n(1 + \beta + \lambda - \frac{X_t}{Y_t^n}) \tag{3}$$

where $\beta = FA_t^n/Y_t^n$ and $\lambda = IT_t^n/Y_t^n$.

During normal times the economy is growing with an average growth rate g. When the crisis hits the economy GDP drops by γ%.

$$Y_t^n = (1 + g)Y_{t-1}^n \tag{4}$$

$$Y_t^c = (1 - \gamma)Y_t^n \tag{5}$$

$$\gamma = 1 - \frac{Y_t^c}{Y_{t-1}^n(1+g)} \tag{6}$$

where Y_t^n is GDP in normal times, and Y_t^c is GDP during the crisis.

After the crisis the consumption will be lower because of the capital outflows and the decline in private transfers. Additionally, these two shocks affect the economy as a whole so the total income in the economy will also be lower by γ%. On the other hand, the government uses an amount of the international reserves to smooth consumption during crisis.

$$C_t^c = Y_t^c + FA_t^c + IT_t^c + R_t - X_t \tag{7}$$

C_t^c is the consumption after the crisis, FA_t^c and IT_t^c are the financial account and the private transfers after the crisis, whereas R_t are the international reserves. Again, in order to express the shocks as a percent of GDP we modify equation (7)

$$C_t^c = Y_t^n(1 - \gamma + \underline{\beta} + \underline{\lambda} + \frac{R_t - X_t}{Y_t^n}) \tag{8}$$

where γ is the output shock, explained earlier and $\underline{\beta}$ and $\underline{\lambda}$ are the financial account and income and transfers account, expressed as a percent of GDP, during the crisis.

The role of the government in this model is to insure the private sector against negative shocks by smoothing private sector's consumption at the moment of the shock. As in Jeanne and

[10] Consumption and domestic absorption are considered the same in the model.

Ranciere (2011) we assume that the government signs 'an insurance contract' with the foreign investors which states that the government has to pay certain resources $X_t = x_t R_t$ during normal times in order to receive insurance i.e. transfer of international liquidity R_t , when the shocks hit the economy. Modeled in this way, the behavior of the government reflects, though in a simplified way, the trade-offs that exist in reserve management i.e. there are certain resources that must be sacrificed in good times in order to have access to international liquidity in 'bad' times. X_t appears with a negative sign in the consumption equation (2) because the government is paying the 'insurance premium'. During crisis government is paying the insurance $x_t R_t$ for the last time, but also receives an amount of positive transfer given by R_t (equation (7).

Defined in this way the insurance premium x_t is exogenous to the model. To simplify the calibration of the model it is useful to endogenize x_t. Following Jeanne and Ranciere (2011) we assume that the government issues long-term liabilities whose payoff is contingent on the occurrence of the crisis, instead of signing an insurance contract. The face value of this liability is equal to one and it is repaid only if there is no crisis. This debt yields $(1 + r + x_t)$ in normal times and $(r + x_t)$ if there is a crisis in the next period. The government invests the resources from selling securities in reserves that yield low, riskless interest rate r. From here the net payoff for the government is equal to:

$$(1 + r)R_t - (1 + r + x_t)R_t = -x_t R_t \text{ in normal times} \tag{9}$$

$$(1 + r)R_t - (r + x_t)R_t = (1 - x_t)R_t \text{ in crisis} \tag{10}$$

where R_t is the value of the securities being issued. In this case, instead of insuring the country by signing 'insurance contract', the government can hold certain amount of international reserves that is being financed by issuing long-term debt with x_t representing the interest rate spread on the long-term debt. Since the securities are used for purchasing reserves, the number of sold securities will be equivalent to the amount of international reserves held by the government.

$$x_t = \delta_t + \pi_t \tag{11}$$

The interest rate spread is equal to the sum of the pure risk premium, δ and the probability of a crisis π (equation (11)). In this context, the probability of the crisis represents the default premium, because the government stops servicing its debt once the crisis hits the economy. The interest rate spread concept was adopted by Edwards (1985), Garcia and Soto (2004) and Rodrik (2006) to define the opportunity cost of holding reserves. However, as argued by Jeanne (2007) and Jeanne and Ranciere (2011) the interest rate spread overstates the true opportunity cost because the default premium should not be part of the opportunity cost. The default risk premium is the compensation for the risk that the government will not repay its debt if a crisis occurs, and from here, it does not represent any opportunity cost of holding reserves. From here, only δ, the pure risk premium, is the true measure of the opportunity cost.

By substituting the expression for the net payoffs from issuing government bonds and for the interest rate spread in the consumption equations, we obtain the following expressions

$$C_t^n = Y_t^n(1 + \beta + \lambda - (\delta + \pi)\rho) \tag{12}$$

for consumption before the crisis and

$$C_t^c = Y_t^n(1 - \gamma + \underline{\beta} + \underline{\lambda} + (1 - \delta - \pi)\rho) \tag{13}$$

for consumption after the crisis, where ρ stands for R_t/Y_t^n.

The formula for the optimal level of reserves is derived from the maximization problem of the government i.e. the government is expected to maximize the welfare by deciding on the optimal level of international reserves with respect to the budget constraint.

$$max\beta E_t(C_{t+1}) = \ max\beta[(1 - \pi)\mu(C_{t+1}^n) + \pi\mu(c_{t+1}^c)] \tag{14}$$

The first order condition with respect to reserves is equal to

$$(1 - \pi)(\delta + \pi)\mu'(C_{t+1}^n) = \pi(1 - \delta - \pi)\mu'(C_{t+1}^c) \tag{15}$$

The expression $\frac{\mu'(C_{t+1}^n)}{\mu'(C_{t+1}^c)}$ represents marginal rate of substitution between consumption in the sudden stop state and consumption in normal times. We denote it with p and it determines the extent of insurance provided in the domestic economy. If $p = 1$ the consumption in normal times and the consumption in crisis will be the same i.e. there will be full insurance. If $p \leq 1$, then the consumption after the crisis will be smaller than the consumption before the crisis i.e. the insurance only partially offsets the consequences of the crisis. From equation (15) p is equal to:

$$p = \frac{\mu'(C_{t+1}^n)}{\mu'(C_{t+1}^c)} = \frac{\pi(1-\delta-\pi)}{[(1-\pi)(\delta+\pi)]} = \frac{x_t^{-1}-1}{\pi_t^{-1}-1} \tag{16}$$

The Euler equation for consumption will be

$$(C_t^n)^{-\sigma} = p(C_t^c)^{-\sigma} \tag{17}$$

$$(C_t^c) = p^{1/\sigma}(C_t^n) \tag{18}$$

$$\left(1-\gamma+\underline{\beta}+\underline{\lambda}+(1-\delta-\pi)\rho\right) = p^{\frac{1}{\sigma}}(1+\beta+\lambda-(\delta+\pi)\rho) \tag{19}$$

From here the optimal level of reserves is given as:

$$\rho = \frac{\left[\gamma+p^{\frac{1}{\sigma}}(\beta+\lambda)-(\underline{\beta}+\underline{\lambda})\right]+p^{\frac{1}{\sigma}}-1}{1-(\delta+\pi)(1-p^{\frac{1}{\sigma}})} \tag{20}$$

5.2. Model for optimal level of reserves with an exogenous probability of crisis and real exchange rate depreciation

In this section, we extend the model constructed in the previous section to capture the effects of the real exchange rate depreciation. The structure of the model and the basic assumption remain the same; we only assume that the crisis is accompanied by the real exchange rate depreciation. In normal times, the real exchange rate is constant and equal to 1, whereas at the time of the sudden stop the exchange rate changes for certain amount, ΔQ.

$$Q_t^n = 1, Q_t^c = 1+\Delta Q \tag{21}$$

Real exchange depreciation changes the insurance cost p which in this case is equal to

$$p = \frac{\pi(1-\delta-\pi)}{[(1-\pi)(\delta+\pi)]}(1+\Delta Q) \tag{21}$$

In this case the formula for the optimal level of reserves becomes

$$\left(1-\gamma+(\underline{\beta}+\underline{\lambda})(1+\Delta Q)+(1-\delta-\pi)\rho(1+\Delta Q)\right) = p^{\frac{1}{\sigma}}(1+\beta+\lambda-(\delta+\pi)\rho) \tag{23}$$

$$\rho = \frac{\left[\gamma + p^{\frac{1}{\sigma}}(\beta+\lambda) - \left(\underline{\beta}+\underline{\lambda}\right)(1+\Delta Q)\right] + p^{\frac{1}{\sigma}} - 1}{(1-\delta-\pi)(1+\Delta Q) + p^{\frac{1}{\sigma}}(\delta+\pi)} \qquad (24)$$

Intuitively, one would expect higher optimal level of reserves in the model with real exchange rate depreciation as compared to the baseline model. First, the same amount of reserves provides more insurance than in the model without depreciation, because the value of reserves in terms of domestic consumption increases at the time of the sudden stop (increase in wealth), which reduces the cost of insurance. Second, the size of the external shocks increases with real exchange rate depreciation. Cheaper insurance and larger shocks will increase the demand for insurance i.e. the estimated level of optimal reserves will be higher.

5.3. Model for optimal level of reserves with an endogenous probability of crisis

The basic model for optimal level of reserves presented in Section 5.1 assumes that reserves serve for mitigation of the negative effects of a crisis by smoothing consumption. However, as argued by Bassat and Gotleb (1992), Garcia and Soto (2004) and Jeanne (2007), international reserves can have an additional preventive role against future crisis. The idea is that higher level of reserves reduces the probability of a crisis i.e. the probability of a crisis is a decreasing function of the foreign reserves

$$\pi_t = \pi(\rho_t) \qquad (25)$$

This function of the international reserves closely resembles the behavior of the Central Bank in a fixed exchange rate regime. By holding higher level of reserves the Central Bank signals its commitment to defend the fixed rate and from here, reduces the probability of a crisis.

The baseline model structure is kept the same. The only difference is that in this model we endogenize the probability of a crisis. Once π_t is endogenous, there is no analytical solution for the model i.e. one have to solve for the optimal reserves using numerical techniques. This is because the relationship between the probability and the reserves is two-sided. The government decides on the optimal level of reserves, but this level will depend on the probability of a crisis. However, by choosing the optimal level of reserves the government also influences the probability of a crisis. Therefore, a numerical algorithm known as the value function algorithm is used to calculate the optimal level of reserves. The optimal level of reserves is equal to the value function $\tilde{V}$:

$$\rho *= \arg max \, (\tilde{V}(\rho) \equiv \big(1-\pi(\rho)\big)\tilde{U}^n(\rho) + \pi(\rho)\tilde{U}^c(\rho) \tag{26}$$

where $\tilde{U}^n$ is the welfare in normal times and $\tilde{U}^c$ is the welfare in crisis.

$$\tilde{U}^n(\rho) \equiv u\big(1+\beta+\lambda-\big(\delta+\pi(\rho)\big)\rho\big) + \frac{(1+g)^{1-\sigma}}{1+r}\tilde{V}(\rho^*) \tag{27}$$

$$\tilde{U}^c(\rho) \equiv u\Big(1-\gamma+\underline{\beta}+\underline{\lambda}+\big(1-\delta-\pi(\rho)\big)\rho\Big) + \sum_{\tau=1}^{\theta}\left[\frac{(1+g)^{1-\sigma}}{1+r}\right]^{\tau} u(1-\gamma(\tau)+\underline{\beta}\,(\tau)+\underline{\lambda}\,(\tau)+ \left[\frac{(1+g)^{1-\sigma}}{1+r}\right]^{\theta+1}\widetilde{U^n}(\rho^*) \tag{28}$$

To solve this fixed point problem we start with an initial guess for the optimal level of reserves equal to the level of reserves from the model with exogenous probability and we iterate forward until we find a stationary solution.

5.4. Model calibration

To calculate the optimal level of reserves one has to calibrate all the parameters in the equations (20, 24, 26). Some parameters are calibrated by using historical data; the rest of the coefficients are based on results from different empirical studies or derived from economic theory. The shocks for Macedonia are calibrated on the basis of two historical episodes - the internal conflict in 2001 and the global economic crisis in 2009.

The first parameter to be calibrated is the probability of a crisis (π). There are several empirical studies that estimated this coefficient by running probit or logit regressions on a sample of panel data (Jeanne and Ranciere (2006), Jeanne (2007) and Gourincas and Obstfeld (2012)). The results generally suggest value of around 10%. For example, Jeanne and Ranciere (2006) estimated the probability of a sudden stop for the average middle income economy to be around 7.9%. If the analysis is made only for one country, as in our case, the usual approach is to calibrate this coefficient. Ceh and Krznar (2009) use 10% for the probability of crisis in the case of Croatia. Goncalves (2007) calibrated the sudden stop probability for Uruguay to 7.5%. For Macedonia, we calibrated this coefficient to 7.5% - slightly smaller than the widely used benchmark of 10%. However, in the next section we make sensitivity analysis to check the sensitivity of the reserves to changes in π. An alternative approach would be to try to estimate the probability of a crisis by using a sample of countries[11] with similar fundamental characteristics as Macedonia, but because of the small sample size we believe that the results will be insignificant and unstable.

The opportunity cost of holding reserves is usually measured as the difference between the return on reserves and the return on a more profitable asset (Jeanne, 2007). The return on reserves is usually proxied as the return on short-term, risk free, foreign currency asset. The problematic part is the definition of the alternative investment opportunity. One can consider physical investment as an alternative investment opportunity; however it is very difficult to measure the marginal product of capital needed to calculate the return on this investment. An alternative would be to measure the opportunity cost as the spread between the interest rate on country's external debt and the return on its reserves. This comes from the fact that "reserves can be accumulated by issuing - or can be used to repay - external debt" (Jeanne, 2007, p. 27).

$$\delta_t(j) = r_t^l(j) - r_t^s(i) \tag{29}$$

where $\delta_t(j)$ is the opportunity cost of reserves for the country j, $r_t^l(j)$ is the interest rate on the country j's long-term external debt and $r_t^s(i)$ is the country i's short-term interest rate on reserves. This is equivalent to the sum of the country i's term premium and the spread on the country j's long-term debt.

$$\delta_t(j) = r_t^l(i) - r_t^s(i) + r_t^l(j) - r_t^l(i) \tag{30}$$

where $r_t^l(i) - r_t^s(i)$ is the country i's term premium and $r_t^l(j) - r_t^l(i)$ is the country j's spread on long-term debt.

The problem with this approach is that it overestimates the true opportunity cost because, as shown in Section 5.1, the country spread includes the default risk premium on foreign debt. The default risk premium is the compensation for the risk that the government will not repay its debt if a crisis occurs, and from here, it does not represent any opportunity cost of holding reserves. Hence, when using the country spread, one should take into account only the pure risk premium on the country j's debt.

[11] This sample would include mainly the SEE countries, and possible some of the CEE countries. Having in mind the limited history that these countries had with the currency crisis, the crisis sample will be insufficient to obtain meaningful results.

Having all this in mind, we calibrate the opportunity cost in the following manner. First, the country i's term premium is calibrated as the average difference between the yield on 10-year German government bond and ECB repo rate in the period 1999-2007 which is equal to 1.3%, as in Ceh and Krznar (2008). The second part should represent only the pure risk premium on Macedonian long-term external debt. In the empirical literature this component has been found to be relatively small for emerging markets - Kinger et al. (2004) find that the pure risk premium is zero, whereas in Broner et al. (2007) the risk premium ranges between 0 and 1.5%. Having in mind that we do not have any estimate for the pure risk premium for Macedonia it was decided to calibrate it to zero in the baseline scenario and then, to try different alternatives in the sensitivity analysis. With pure risk premium of 0%, the opportunity cost of holding reserves will be equal to the term premium i.e. to 1.3% in the baseline. The interest rate in the model with endogenous probability of crisis, parameter r, represents the return on reserves and is equal to an average foreign risk-free interest rate. In our case, the foreign risk-free interest rate is calibrated to be equal to 3%, which is close to average of six-month Euribor rate[12], as in Ceh and Krznar (2008).

The relative risk aversion coefficient σ is calibrated to the standard value from the real business cycle theory i.e. to 2[13].

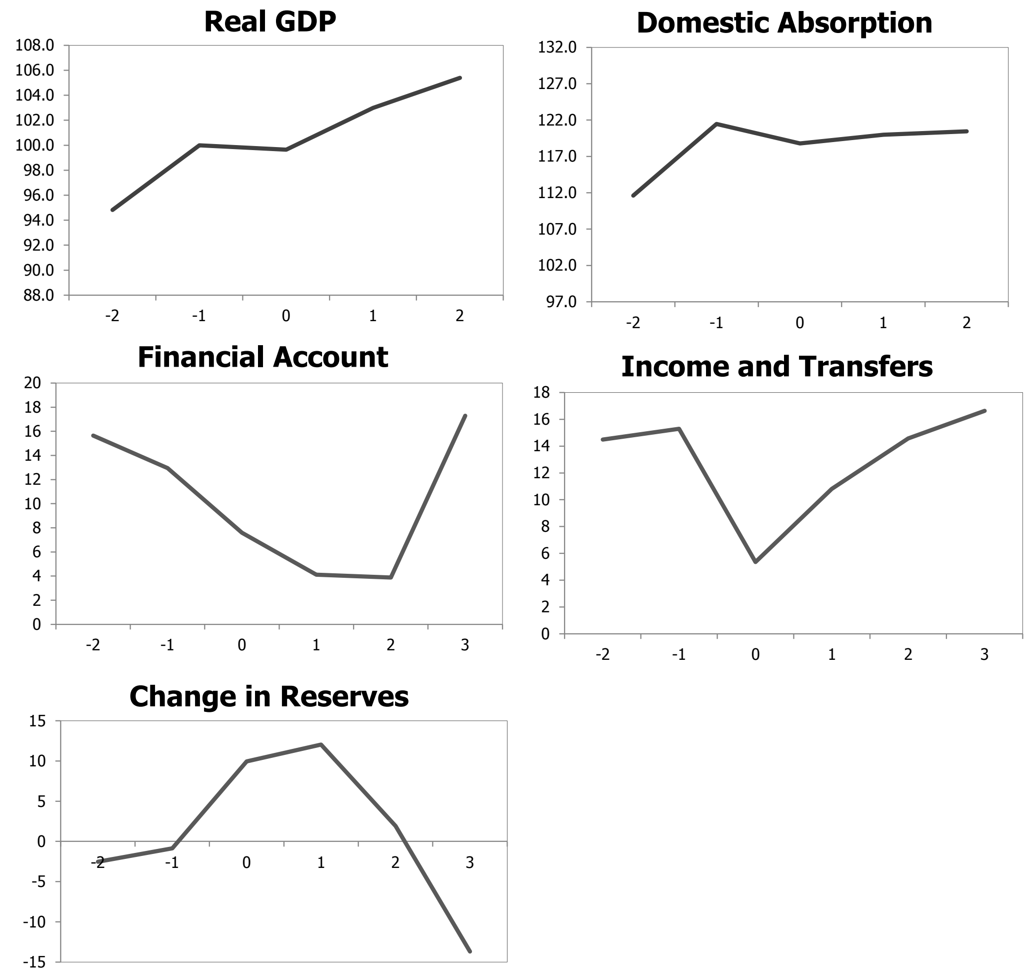
The financial account, income and transfers and the GDP shocks are calibrated by using historical data for Macedonia. More specifically, the coefficients are calibrated by using data from 2009 - the year of the global economic and financial crisis. As a robustness check for the magnitude of the shocks we have used data from 2001 - the year of the internal conflict. Both calibration gave quite similar results. The output loss during the crisis (γ) is calculated to 4.8% with g being equal to 4.3% (the average growth rate of real GDP in the period before the crisis 2002-2008). For identification of the financial, as well as the income and transfers shock we have used quarterly data. Namely, if one investigates annual data one cannot identify any negative shock in 2009 because the shocks started in the last quarter of 2008 and they were very short-lasting. Therefore, to measure the decline one has to use quarterly data. Within the quarterly series, the financial account before the shock was around 17% of GDP whereas after

[12] This calibration is based on the average value of six-month Euribor rate for the period 1999-2011.

[13] Many empirical studies based on actual behavior of individuals have been conducted in order to determine the value of the relative risk aversion parameter. These studies yielded estimates for the relative risk aversion coefficient in the range of 1 to 4, with a mean value for of $\sigma = 2$.

the shock it fell to 3.9%. Similarly, income and transfers account expressed as a percent of GDP was equal to 15% before the shock and it declined to 5.4% of GDP afterwards.

Figure 6



Note: The time of the shock is denoted with 0. Domestic absorption and domestic output are expressed in percentage points of real gross domestic product (GDP) in the year before the sudden stop. The financial account (excluding changes in reserve assets), income and transfers and the change in reserves are expressed in percent of GDP. A positive change in reserves corresponds to a loss of reserves. For identification of the shock, annual data is used for GDP and domestic absorption, whereas for the financial account, income and transfers and the quarterly change in reserves we have used quarterly data. The timing of shock is 2009 for annual data and 2008 q4 for quarterly data.
Source: NBRM, SSO and authors' calculations.

To calibrate ΔQ from past data is not easy, because the real exchange rate is quite stable in recent years even during the crisis year (2009). Instead, we just assumed real exchange rate depreciation shock of 10%.

For the model with endogenous probability we use the same calibration as in the baseline model. Additionally, we need to calibrate two more parameters that are connected with the functional form of the endogenous probability of a crisis. We assume that the probability of crisis is the probit function of reserves:

$$\pi_t = F(b - a\rho_t) \tag{31}$$

Parameter b captures the country's fundamental factors that might influence the probability of a crisis, such as different external and internal imbalances of the country. Parameter a is the prevention benefit parameter and represents the relationship between the reserves ratio and the probability of a crisis. If $a = 0$, the model collapses to the model with exogenous probability of a crisis. In our baseline calibration we calibrate a to be equal to 0.15. This is the value used in Ceh and Krznar (2009) for Croatia. The benefits of reserves in terms of crisis prevention have been confirmed in several empirical studies. However, a is estimated to be statistically significant only in cases of currency crisis (Jeanne, 2007) and banking crisis (Gourinchas and Obstfield, 2012), but no evidence has been found in the case of sudden stops. By running 180 probit regressions on a large sample of countries that experienced either sudden stops or currency crisis, Jeanne (2007) estimated a to be between 0.2 and 0.3 in the case of currency crisis. The coefficient was not significant in the case of sudden stops. Gourinchas and Obstfield (2012) used a logit model for explaining the probability of a banking crisis and currency crisis in emerging markets. Their results confirmed the significant prevention role of the reserves with the marginal effects being estimated to 0.3, in the case of a banking crisis and around 0.7, in the case of a currency crisis[14]. In order to check the sensitivity of the optimal level of reserves to the crisis prevention parameter, in the next section we make a sensitivity analysis by varying a in the range [0, 0.6]. To calculate value for b we start from $a = 0$ and probability of a crisis equal to the exogenous probability of a crisis i.e. $\pi_t = 0.75$. This gives us value for b equal to -1.44. The optimal level of reserves is then calculated by using the value function iteration algorithm.

[14] The coefficients in Jeanne (2007) and Gourinchas and Obstfield (2012) are not directly comparable because Jeanne used a probit model, whereas Gourinchas and Obstfield used logit model. Additionally, Gourinchas and Obstfield present the marginal coefficients i.e. $\partial\pi/\partial\rho$. The comparable values would be around 0.1 for banking crisis and around 0.3 for currency crisis, which is quite similar to Jeanne's results.

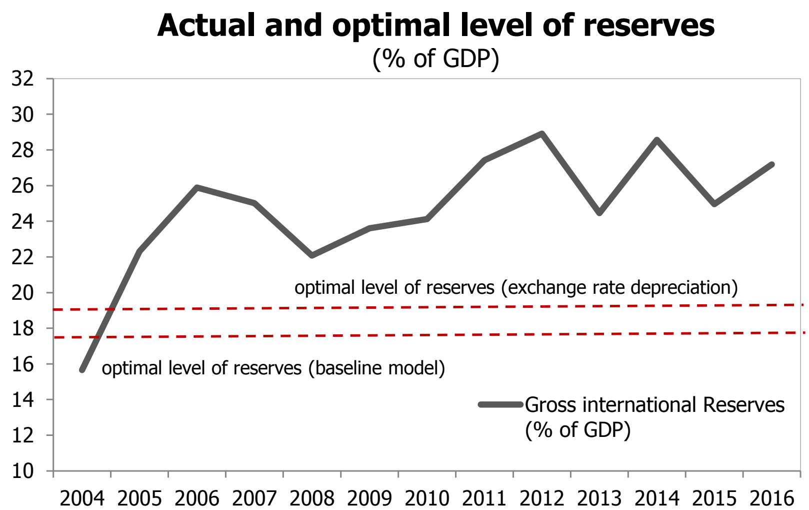
Table 1: Parameter values

		baseline calibration
π	probability of a sudden stop	7.5%
δ	the opportunity cost of holding reserves	1.3%
σ	relative risk aversion	2
p	degree of insurance	0.84
g	GDP potential growth	4.3%
γ	GDP loss	4.8%
β	financial account before the shock	17%
λ	income and transfers before the shock	15%
$\underline{\beta}$	financial account after the shock	3.9%
$\underline{\lambda}$	income and transfers after the shock	5.4%
ΔQ	real exchange rate depreciation	10%
r	risk-free interest rate	3%
a	prevention benefit parameter	0.15
b	fundamental risk parameter	-1.44

5.5. Results and sensitivity analysis

The baseline calibration of the model with exogenous probability of a crisis suggests that the optimal level of foreign reserves for Macedonia is around 17% of GDP. Model version with exchange rate depreciation suggests 2 percentage points higher level of reserves - the optimal level of reserves in this case is calculated to be around 19% of GDP. These estimated levels are well below the actual level of foreign reserves in recent years. In fact, the estimated optimal reserves are lower than the actual reserves starting from 2005 (Figure 7). Only in 2004 the actual level of reserves (16% of GDP) was below the optimal. Thus, the insurance model suggests that the official foreign reserve holdings in Macedonia are significantly higher than what would be optimal from the welfare perspective.

Figure 7

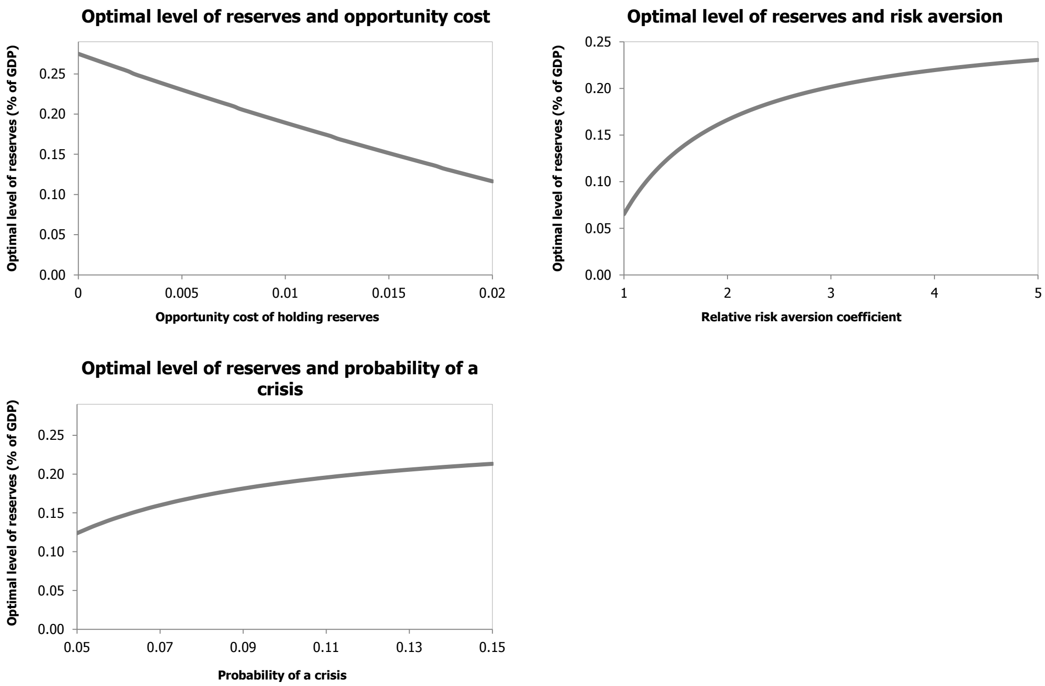


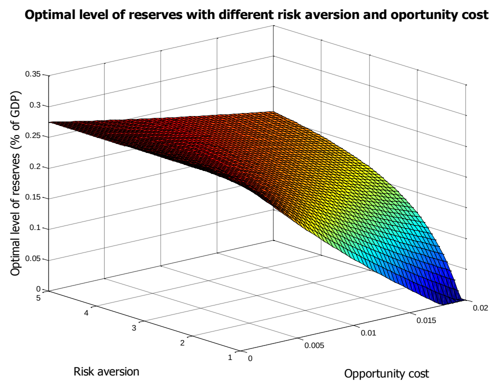
Next, we change the calibration of three structural parameters - the opportunity cost of holding reserves (δ), the probability of a crisis (π) and the risk aversion coefficient (σ) in order to show the sensitivity of the results to different values of the parameters. Namely, as mentioned previously, the values for these coefficients are based on theory and various empirical studies and are not derived from historical data of the Macedonian economy. In this exercise we vary the opportunity cost from 2% to 0%, the risk aversion coefficient form 1 to 5 and the probability of a crisis from 5% to 15%. The exercise consists of two parts - first, we change one by one parameter keeping the other coefficients the same and second, we change two by two parameters simultaneously. The results are shown in Figure 8.

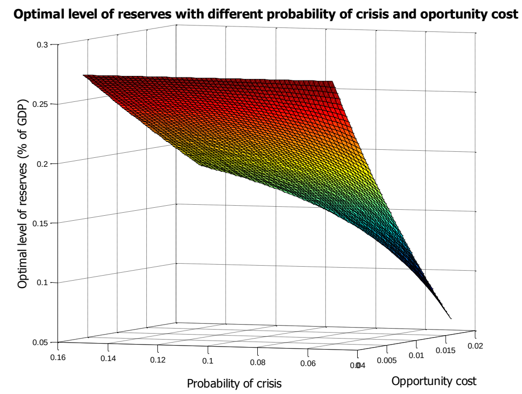
As expected, the optimal level of foreign reserves is higher with the higher probability of a crisis and the risk aversion of the policymakers and/or smaller opportunity cost of holding reserves. Conclusions are similar when two parameters are changed simultaneously. For example, if we assume that probability of crisis increases, it is expected that the risk aversion will increase at the same time. In this case, if the probability of crisis increases to 12%, and we assume that the risk aversion increases to 4.5, then the optimal level of reserves will be 24% of GDP. In our simulation exercise the highest optimal level of reserves (around 28% of GDP) is obtained when $\delta = 0$ and for different values of the other two parameters.

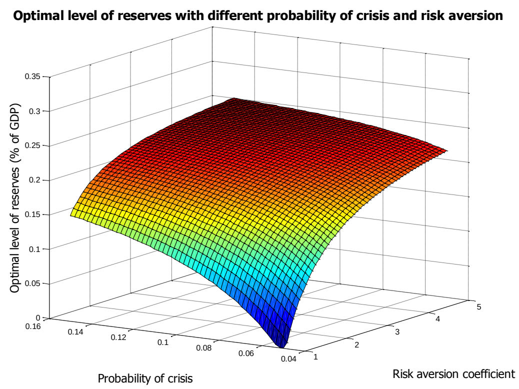
Figure 8

Optimal level of official foreign reserves and changes in the opportunity cost, risk aversion parameter and probability of a crisis



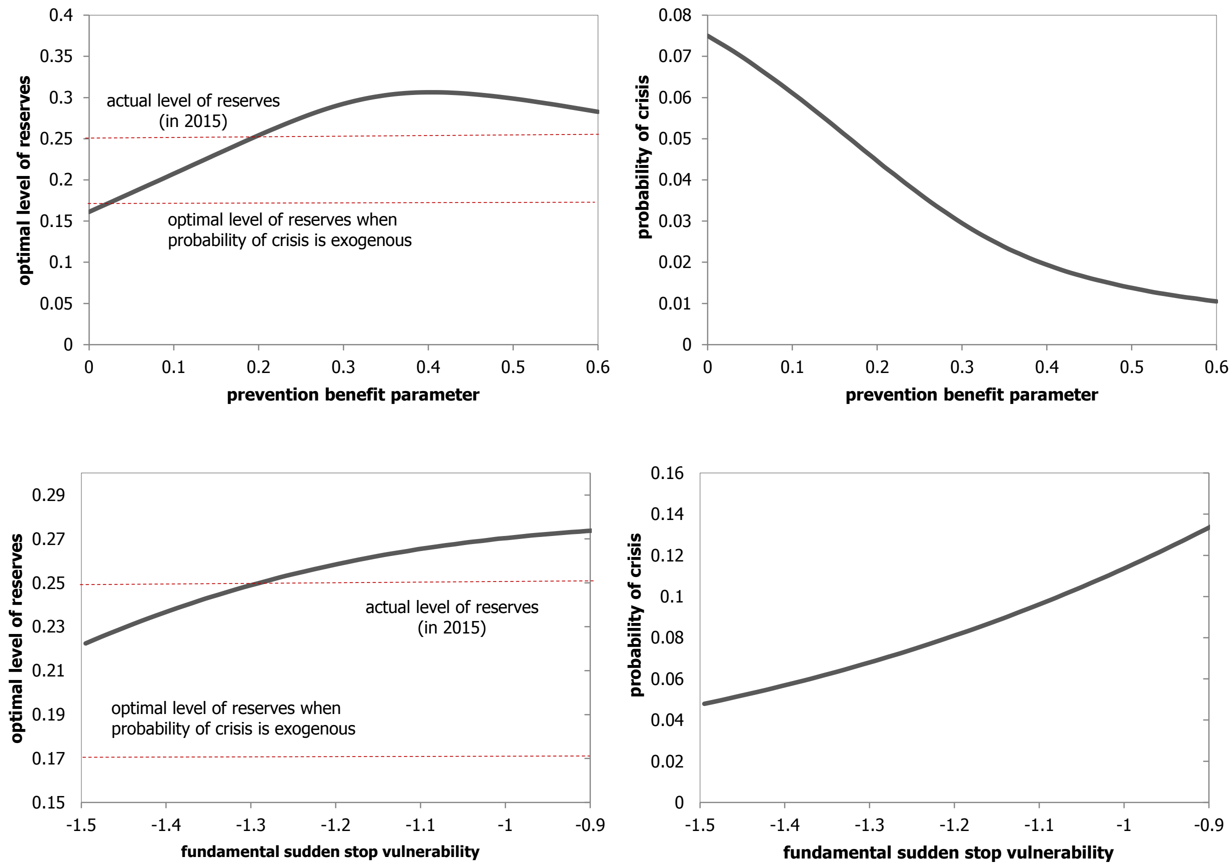






The results presented above are from the model with exogenous probability which implies that reserves are held only for crisis mitigation purposes. However, having in mind the current monetary strategy (i.e. fixed exchange rate regime), as well as the structural characteristics of the Macedonian economy we believe that the model with the endogenous probability of a crisis is more realistic approach for estimating the optimal level of reserves for the Macedonian economy. Namely, with the endogenous probability of a crisis one implicitly assumes that the reserves are held not only for crisis mitigation, but also for crisis prevention purposes. The insurance model with endogenous probability of a crisis with the same calibration as the model with exogenous probability and prevention benefit parameter calibrated to 0.15 gives 24% reserves ratio to GDP as an optimal level of reserves, which is still below, but close to the actual level of reserves in 2015. Figure 9 shows the sensitivity of the optimal level of reserves to changes in parameters a and b. The upper two figures show the optimal level of reserves and the probability of a crisis for different values of the prevention benefit parameter (parameter a), when the country fundamental factors' parameter (parameter b) is equal to -1.44. As expected, the higher the value of parameter a the higher the level of optimal reserves and the lower the estimated probability of a crisis. This relationship is non-monotonic i.e. the higher the value of a the smaller the incremental increase in the optimal level of reserves. The lower two figures show the optimal level of reserves and the probability of a crisis for different values of parameter b, when parameter a is set equal to 0.15. The figures show that the level of optimal reserves and the probability of a crisis increase as the country becomes more vulnerable (i.e. with higher values of parameter b).

Figure 9
Optimal level of official foreign reserves and changes in crisis prevention parameter and fundamental risk parameter



To summarize, the model for optimal level of reserves and exogenous probability of a crisis suggests that the actual level of reserves in Macedonia is above the welfare optimal level. The presented sensitivity analysis showed that the optimal level varies with changes in parameters – the estimated level of optimal reserves is higher with the higher coefficient of risk aversion and probability of a crisis and/or smaller opportunity cost of holding reserves. In addition, we employed insurance model with endogenous probability which implicitly assumes that reserves are held for crisis prevention purposes having in mind the structural characteristics of the Macedonian economy and the current monetary strategy. Within this model, the optimal level of reserves will be around 24% of GDP which is still below, but close to the actual level of reserves in 2015.

6. CONCLUSION

In the case of Macedonia, the building of the official foreign reserve assets was essential, as the National Bank of the Republic of Macedonia is implementing de facto fixed exchange rate monetary regime since 1995. The recent data shows foreign reserves level of 25% of GDP at the end of 2015. However, the continuous building of foreign reserves arises the question of holding the optimal level of official foreign reserves and the reasons for foreign reserves accumulation.

The most used approach in assessing the adequate level of foreign reserves is through cover indicators. In general, most of the cover indicators for assessing the adequacy of foreign reserves show that actual reserves are in line with/or above the benchmark indicators in the analyzed period. The actual reserves exceed the broad money indicator and the import coverage indicator almost in the whole analyzed period. Results are similar for the Greenspan-Guidotti rule, whereas the expanded Greenspan-Guidotti rule suggests slightly higher need for reserves than actual in the first half of the analyzed period. However, in the last five years, as the current account deficit declines, the actual reserves are in line with, or slightly above the proposed benchmark. According to the risk-weighted metric, which covers more than one risk dimension, the level of reserves moves within the proposed range of 100-150% of the metrics, indicating that the actual reserves are at the adequate level for the analyzed period.

Furthermore, we estimated the optimal level of foreign reserves based on cost-benefit welfare model, taking into account the issues related to self-insurance and crisis prevention. Given calibrated parameters, the model with exogenous probability of a crisis, with or without exchange rate depreciation, shows estimated level of optimal reserves below the current level, suggesting that the official foreign reserve holdings in Macedonia are higher than what would be optimal from the welfare perspective. However, given the current monetary strategy and the structural characteristics of the Macedonian economy, we believe that the model with endogenous probability of a crisis, which implicitly assumes that reserves are held for crisis prevention purposes, as well, is more realistic approach for estimating the optimal level of reserves in Macedonia. Within this model the optimal level of reserves will be around 24% of GDP, which is still below, but close to the actual level of reserves in 2015.

References

Aizenman, J., & Marion, N. (2002). The High Demand for International Reserves in the Far East: What's Going on? *NBER Working Paper Series, No.9266*.

Ben Bassat, A., & Gottlieb, D. (1992). Optimal International Reserves and Sovereign Risk. *Journal of International Economics 33*, 345-62.

Broner, F., Lorenzoni, G., & Schmukler, S. (2007). Why Do Emerging Economies Borrow Short Term? *CEPR Discussion Paper 6249*.

Caballero, R., & Panageas, S. (2007). A global equilibrium model of sudden stops and external liquidity management'. *manuscript, MIT, Department of Economics.*

Ceh, A. M., & Krznar, I. (2009). Optimal International Reserves of the CNB with Endogenous Probability of Crisis. *CNB Working Papers*.

Durdu, C., Mendoza, E., & Terrones, M. (2009). Precautionary demand for foreign assets in emerging economies: an assessment of the new mercantilism. *Journal of Development Economics, vol. 89*, 194–209.

Edwards, S. (1985). On the Interest-Rate Elasticity of the Demand for International Reserves: Some Evidence from Developing Countries. *Journal of International Money and Finance 4(2)*, 287-95.

Force, I. R. (2006). The Accumulation of Foreign Reserves. *ECB Occasional Paper Series, No.43*

Frenkel, J., & Jovanovic, B. (1981). Optimal international reserves: a stochastic framework. *Economic Journal, vol. 91(362)*, 507–14.

Garcia, P. S., & Soto, C. (2004). Large Hoarding of International Reserves: Are They Worth It? *Working Paper 299, Central Bank of Chile*.

Gonçalves, F. M. (2007). The Optimal Level of Foreign Reserves in Financially Dollarized Economies:The Case of Uruguay. *IMF Working Papers*.

Gourinchas, P.O., & Obstfeld, M. (2012). Stories of the Twentieth Century for the Twenty-First. *American Economic Journal: Macroeconomics* , 4(1): 226-265.

Heller, H. R. (1966). Optimal International Reserves. *Economic Journal 76 no. 302*, 296–311.

IMF. (2003). Are Foreign Exchange Reserves in Asia Too High. *World Economic Outlook*, 78-92.

IMF. (2011). Assessing Reserve Adequacy. IMF *Policy Paper*.

Jeanne, O. (2007). International Reserves in Emerging Market Countries: Too Much of a Good Thing? *Brooking Papers on Economic Activity*, 1-80.

Jeanne, O., & Ranciere, R. (2011). The Optimal Level of International Reserves for Emerging Market Countries: a New Formula and Some Applications. *Economic Journal*, 905-30.

Jeanne, O., & Rancière, R. (2006). The Optimal Level of International Reserves for Emerging Market Countries:Formulas and Applications. *IMF Working Papers, WP/06/229*.

Jeanne, O., & Wyplosz, C. (2003). The International Lender of Last Resort: How Large Is Large Enough? *in Michael Dooley and Jeffrey Frankel, eds., Managing Currency Crises in Emerging Markets, University of Chicago Press* , 89-118.

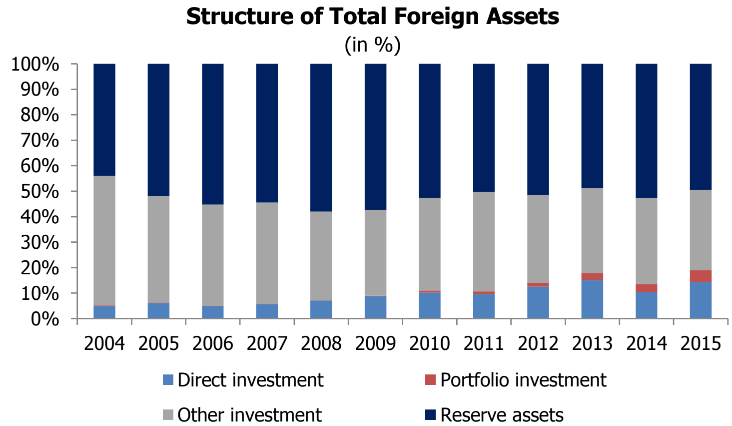
Klingen, C., Beatrice, W., & Zettelmeyer, J. (2004). How Private Creditors Fared in Emerging Debt Markets, 1970-2000. *IMF Working Paper 04/13*.

National Bank of the Republic of Macedonia.(www.nbrm.mk).

Rodrik, D. (2006). The Social Cost of Foreign Exchange Reserves. *International Economic Journal 20(3)*, 253-66.

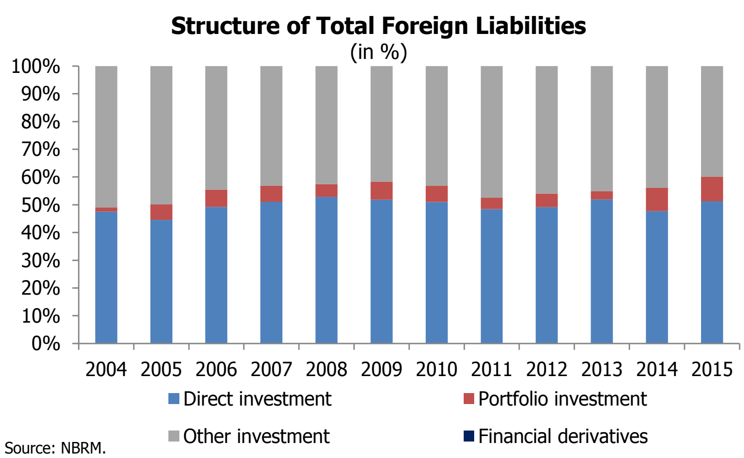
Appendix 1 - Macedonian foreign reserves developments

Figure 1



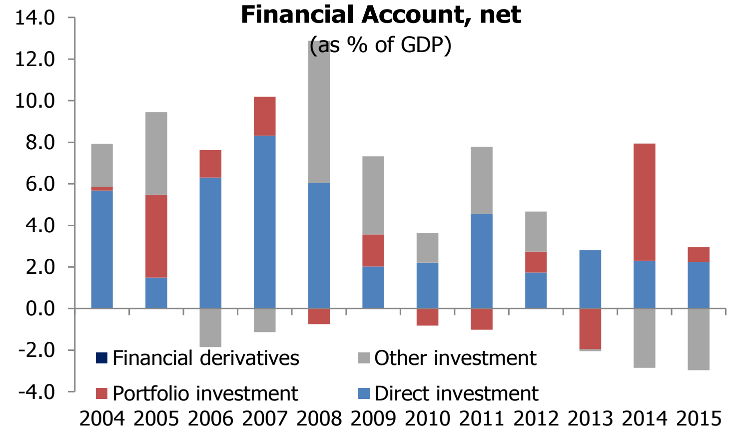
Source: NBRM.

Figure 2



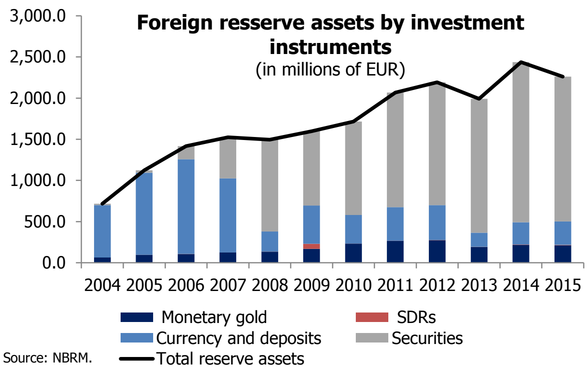
Source: NBRM.

Figure 3

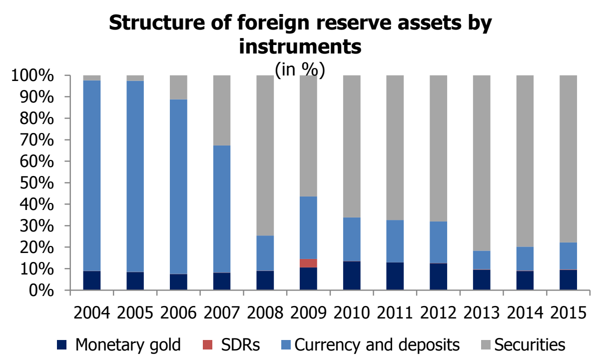


Source: NBRM, SSO and authors calculations.

Figure 4



Source: NBRM.



Source: NBRM.